

NASA ADVISORY COUNCIL
SPACE OPERATIONS COMMITTEE

February 8, 2011

NASA Headquarters

Washington, DC

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Meeting Report Prepared by:
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PARTICIPANTS

<i>Space Operations Committee Members</i>	<i>Guests</i>
Chair: Col. Eileen Collins Vice-chair: Dr. Pat Condon Dr. Leroy Chiao [absent] Dr. John Grunsfeld Mr. Tommy Holloway Ms. JoAnn Morgan Mr. Bob Sieck	Steve Beam / Public Brian Cleaver / Intern-interest Lynn Cline / NASA William Gerstenmaier / NASA Bill Hill / NASA Kate Kronmiller / USA Chuck Larsen / FAA Bill Mackey / CSA Phil McAlister / NASA Frank Morris Dalal Najib / Nat'l Academy of Sciences Richard Rogers / Stellar Solutions Peter Shankmas / NASA Heather Smith / Nat'l Academy of Sciences Mark Uhran / NASA Frank Van Rensselaer / Harris Corp
Mr. Jacob Keaton, Executive Secretary	Winfield Swanson, <i>rapporteur</i>

Mr. Keaton called the meeting to order at 8:04 AM and read requirements for Federal Advisory Committee Act (FACA) meetings. Col. Collins welcomed everyone, reminding them of this committee's mission, namely, advising the NASA Administrator through the Advisory Council.

DISCUSSION—BILL GERSTENMAIER

Shuttle Flights. NASA's focus is to fly the 3 remaining Shuttle flights safely, which is not easy with the break between the last flight and the next one, and the continuous lay-offs in Florida. The intertank stringer problem was not easily corrected, but the team continued to stay focused and we are now prepared for the flight readiness review for the February 24 flight. April 19 and June 28 are the following two scheduled launch dates. Team morale seems good overall, but we must remain watchful to be sure that continues, as more people are laid off, and we lose the depth and flexibility we once had. Also, building different parts in different places generates lots of paper work. Through it all, our overriding concern is that we ensure that flights occur safely. The budget has not changed, but prior to December, the decision was made to find the money for flight #135. A final layoff had been planned for after April, but that may be relaxed so as not to stress the flight #135 teams.

Space Station. Meanwhile, the International Space Station (ISS) is undergoing an unbelievably busy time. The Automated Transfer Vehicle (ATV) will be launched Feb 15th, and 2 days later the Shuttle will dock. ISS will be receiving H-II Transfer Vehicle, the ATV, Progress, and a Shuttle within a month, in addition to the Shuttle manifest. Coordination is essential, e.g., if HTV slips a day, so will the Shuttle launch. And, there are tremendous logistical intricacies among these activities, e.g., HTV must move so the Shuttle tail does not hit it. The Canadian robot

Dextre was first used to move two boxes off the pallet. The Station team is executing these maneuvers, but tremendous flexibility is required and also as scientific research is being conducted simultaneously.

Commercial Cargo. Whether to combine two missions into one, or keep them separate is under discussion for the next SpaceX flight. One of the many challenges is that the communications link from the Station to Dragon violates communications standards because the frequency is also used by other government agencies around the world. It is geared for EVA, but to increase power, it interferes with other communications. There is also a problem with the grapple fixture on the Dragon capsule; and when the vehicle berths, it plumes the solar rays. However, industry can change their software faster than NASA can analyze the impacts, so NASA has a lot of work to do in this first year for commercial cargo. The July date may slip to 2012.

Space Communications. Tracking and Data Relay Satellites (TDRS) K (the communication satellite manufactured by Boeing) is beginning thermal vacuum tests, and a launch is scheduled for April 2012. Most satellites are 20 years old and beginning to fail. Other initiatives are the Space Network Ground Segment Sustainment (SGSS) upgrade for the White Sands satellite upgrade computing and signal processing equipment, and replacement of the Deep Space Network 70-m dishes with 36-m dishes and installing new antennas at the Canberra Space Centre, Canberra, Australia. (The handover occurs in 2025.)

Launch Services. This calendar year, 6 launches are scheduled: Glory, February 23; Two Plantetarys in the fall; followed by the Delta-2, Falcon-9, and Taurus-2. Jim Norman was appointed Assistant Associate Administrator for Launch Services to oversee these services. We need to keep facilities available for rocket propulsion testing.

Medical Equipment. NASA is seeking innovative ways to acquire medical equipment on board the Space Station. A commercial company will modify its hardware to suit our needs, e.g., automated external defibrillators (AED) have one diode, but we need two diodes. Meanwhile, the Food and Drug Administration (FDA) will now require all AED manufacturers to make NASA's two-diode model because it will improve reliability. Likewise, NASA used to have to have equipment customized to comply with its 6-foot drop requirement, but that is now produced and available commercially. We will also be flying new devices to measure ocular pressure and intracranial hypertension.

Budget and Operations. This year is unique because in the middle of a budget cycle we have no FY2011 budget and are operating under a Continuing Resolution at a time when we will get the FY2012 (February 14) and are preparing for the FY2013 budget. There has been some informal discussion regarding combining Exploration Systems Risk Management with Space Operations.

Discussion

- *Col. Collins* asked for suggestions for what the committee should see while at Kennedy Space Center (KSC) for the next meeting. *Mr. Gerstenmaier:* Congress has tasked NASA with looking at ideas for the 21st Century, and the planning for this can be discussed. Some heavy lift development and ground operations will come from this 21st Century activity. At KSC they are trying to make their facilities more generic rather than

having each geared for a single vehicle.

Bill Hill suggested activities around partnering with other people in support of commercial entities both vertically and horizontally. Activities for the 21st Century are a joint effort. Star Fighters fly F-104s in and out, and they are looking to expand, and, once the Shuttle is terminated, NASA will be left with a large and long runway.

Mr. Gerstenmaier recommended visiting Launch Complex 40 to see Space-X's system for an electronic approval procedure. It is a much more streamlined information-distribution system, which obviates physically moving paper.

- *Dr. Condon* asked about the Space Station's role in preparing for flights out of low Earth orbit.
Mr. Gerstenmaier: NASA tasked the Station Program to look at long-duration missions in summer 2012 that would include training the crew for a 30-day simulated Mars mission. The activity is being reviewed to see what needs to be done, e.g., freezing consumables on orbit. They are looking at the Russians' Mars-500 flight simulations. *Dr. Grunsfeld* observed that the critical element in a 6-month ISS trip, except for radiation, is the same as it would be for a trip to Mars. The real concern, is whether you can perform—driving rovers or whatever—when you land. *Mr. Gerstenmaier* assured him that was included in their discussions.
- *Mr. Sieck* asked about future concerns for ISS operations in light of the experience five years ago with a cracked tank. *Mr. Gerstenmaier:* Lack of engineering support did not deter them in the Shuttle case; it was just a tough problem. They saw that the aluminum-lithium stringers were cracking during manufacture, but it was deemed acceptable in 1997; now they see they should have added more margin. We need to think about how a problem that appears small in the beginning will look in 10 or 20 years. Sometimes we are too focused on today's solution, but we have learned that there's an art to looking forward. We have to watch engineering attrition on orbit. We could lose our engineering workforce if they have no program to go to where they can maintain their skills. People are not concerned about depth of workforce today. It is adequate, but we need it to continue into the next generation or into the commercial realm, and that's a big challenge.
- *Mr. Holloway:* Before we flew the ATV, the terminal phase of approach and docking were certified. How did the two [SpaceX] compare? *Mr. Gerstenmaier:* The certification was not as thorough as what the Europeans have done. DragonEye has flown on the Shuttle and they have done bits and pieces, but much remains to be done in rendezvous. The computers are not radiation hardened, but are commercial grade and subject to single-event upset. Whether this could cause loss of mission is unknown. If two flights were flown, we could factor into the second flight, problems discovered on the first flight. Ultimately, we will protect the Station, but SpaceX and Orbital vehicles could potentially introduce risk. If we think so, we will err on the side of not coming in or aborting. But, if we go into the venture with the right attitude and are prepared to fall back to two flights, we will be OK. The same ISS team is involved as worked on SpaceX and HTV, headed by Kathy Leuders, Manager, Transportation Integration Office.

- Dr. Grunsfeld:* February is pretty late to be talking about software changes when they're pushing for a July launch. At what point do you stop making changes? *Mr. Gerstenmaier:* Considering that they are learning to operate in a new environment, we will allow software modifications until this summer. It is no different than in our own world—if we let engineers tweak, they will tweak forever—and cutting them off is a matter for project management. At this point, the value of the changes is great enough that they need to be allowed. But, when changes are not mandatory, they will not be permitted. Then when we're ready, we'll pick the right time to fly.
- Dr. Grunsfeld:* They need to understand that in a partnership, they have to conform. *Mr. Gerstenmaier:* They can learn from us, and we from them. We have too much process in our system in places; we need the blending. *Dr. Grunsfeld* brought up the interesting Progress test on Mir—not the kind of thing usually done, and it had a bad result. We don't want to repeat that kind of experiment. *Mr. Gerstenmaier* agreed entirely. The perception has to be stated that we will back off when we perceive something is not right. *Dr. Grunsfeld:* The beauty of the ATV test is that they backed out. *Mr. Gerstenmaier:* Dragon is planned to be done the same way—a whole series of fly-ins and then back out. We will verify and validate all that in a series of decision games.
- Dr. Condon:* NASA appears to be in tug of war between the Administration and Congress, and NASA is operating under Continuing Resolution that still has Constellation in the budget, whose workforce for a few generations had clear goals and objectives. In the environment that exists now, how do you structure a plan and communicate that plan to the workforce? *Mr. Gerstenmaier* thought *Dr. Condon* characterized the situation well. We are in a dynamic environment and potentially in two non-aligned directions. It is up to NASA to find commonality between these two positions, knowing our strengths and skills. Then it is up to NASA to build a credible plan. In the past, NASA may have been more responsive to outside forces than it should have, just trying to live within imposed constraints, and we have not had such a plan to date. We have to look at what we technically can do that meets both objectives. At the same time, NASA doesn't make big changes easily and has been asked to make many changes. We also have to know when we have to make decisions (a time-line question). We have contracts for Orion, so we can't drop that plan all at once. Within a capabilities-driven framework, NASA must build an overall plan. In fact, there are many commonalities between the two positions, but building a plan is made more difficult by this very dynamic budget.
- Dr. Grunsfeld:* One of most important recommendations that came from the Columbia Accident Investigation Board was that NASA should transport in the simplest, safest vehicle possible. This included separating the crew and cargo. It has been eight years since then, and we do not want to get complacent. We are starting to learn some of the lessons. *Mr. Gerstenmaier* needed to think about that and to have more of a dialogue. The Russian Soyuz flies both cargo and crew, so it can be tested on the cargo version before committing crew to it, which results in more flight time on the combined system. We need a dialogue about the pluses and minuses to discuss the complexity of the booster

ride, etc. It's a long and complicated discussion. *Mr. Holloway* added that NASA also has to decide how long and how often they are going to use it.

- NAC is not in the day-to-day fray and can be objective, and *Mr. Gerstenmaier* looks forward to its advice and counsel. *Col. Collins* congratulated the work team that analyzed and repaired the stringers, as well as the ISS team. The Station is our #1 priority. *Mr. Gerstenmaier* cautioned that we also have to be sure that the Station is an effective part of the plan.

SPACE SHUTTLE UPDATE—SOMD/BILL HILL

The Shuttle manifest for the next three launches is on track beginning with the first, February 24. There are challenges with #133 and #134 (including the Mark Kelly/Gabrielle Giffords situation).

- *Col. Collins* asked whether the Alpha Magnetic Spectrometer (AMS) would be included in the payload. *Mr. Hill*: That will go in at end of month. They are already collecting good data that prove it will work. Payload on #135 will include the multi-purpose logistics module (MPLM) of stores and spares, and will bring back a pump that failed. No major Space Station components are being taken up. There are already 4 spare ammonia pumps, but we want to see why this one failed.

Shuttle Transition and Retirement. In October, the Space Station and Space Shuttle Program Managers were directed that STS-135 will fly. The Space Shuttle Program (SSP) workforce was planned to average 3457 monthly, but the projected monthly average is in fact 4777. The actual will shift to the June/July timeframe; they have about a month of down-processing. Where Orbiters will go has still not been decided. The timeline shows a plan for three Shuttle flights, but with WARN notice of layoffs. Risk enters with the loss of critical skills and with the involvement of contractors. Voluntary attrition rates continue to decrease or stay level. It could be impacted by the size of recent and upcoming layoffs, the next being in April when they will lose 700 people, mostly in Florida. In March, the Constellation employees will be let go. Nevertheless, people are proud of what they have been doing, and most say they will stay with the program to its end. The problem is determining what they will do when the Shuttle program ends. About 450 KSC and 150 Texas, USA employees were notified of an April 8 separation date; of these about 250 in Florida volunteered. USA has held job fairs to help place them. All prime contractors have critical skills plans in place. Uncertainties in the schedule make the situation more difficult for them, but the #135 decision has mitigated that for now. *Mr. Gerstenmaier*: Notice that #135 will proceed, regardless, has been issued. They are extending prime contracts, e.g., for transition activities that will continue into 2012. They did not plan on closure of Constellation, and now cannot include it in the transition plans. They are working with KSC (and OPF-3 because of isolation), which is interest in de-positioning its assets.

STS-133 External tank Intertank Stringer Cracks. The inspection team found on stringer 7, panel 2, a 9-inch crack on both sides. The 108 stringers on the intertank prevent it from buckling under the weight of the oxygen tank. Doublers were built at 8 different stringers (2, 6, 3, and 7). When the initial 3.5-inch cracks were found in stringers 7 and 6, they did a tanking test after repairs. They also tested stringers on #3 (the mirror image of #6). After the tanking test, they rolled back

to the Vehicle Assembly Building (VAB) to X-ray the back side of the tank where they found three additional cracks. This had been thought to result from assembly stress related to the doublers, but two were not in areas where there were doublers. On the back of panel 2, the surface looked mottled. When tested, it was found to have high strength capability, but low fracture capability. (Aluminum-lithium is quite brittle, not unlike glass.)

Fishbone assessment is complete and indicates that this failure was caused by the combined effects of low-fracture toughness of Al2090 used on intertank stringers, plus residual stresses, defects, and reduced thickness. Radius blocks have been installed to mitigate at LO₂ side for high contributors/scenarios identified by the Fishbone analysis. Successful post-tanking nondestructive evaluation (NDE) results and finite element machine (FEM) analysis data show low probability of cracks occurring on LH₂ stringer ends during ascent. Stringer mid-bay sections are not susceptible to foot bending failure mode. Intertank skin stringer panels are “fail safe” against structural collapse for stringer failure conditions, assuming that three consecutive stringers will crack similar to the observed condition on the LO₂ side. Shuttle Program will be reviewed this Thursday (February 10).

HEAVY LIFT/SPACE LAUNCH SYSTEM BRIEFING—ESMD/CRISTINA GUIDI

The Space Launch System (SLS) is not yet an appropriated program, so they can only do planning activities. February 1, 2010, the President recommended cancelling Constellation and initiating technology programs, including heavy lift and propulsion technology. Initially they wanted to direct work to the liquid propulsion industry, and perhaps seek a common engine that NASA, the Air Force, and the Department of Defense could all use. In mid-April, the President, via the Authorization Act, section 309, instructed NASA to build a heavy-lift launch by 2015. NASA was to present a report within 90 days. Many plans did not comply with budget changes, and they are required to obtain an independent assessment of cost of program. On January 10, NASA submitted a preliminary report of plans for developing a heavy-lift launch, and will send the final report by summer.

No additional money to build the launch vehicle is expected, so it will likely be a follow-on to the Space Shuttle using existing contracts. The vehicle must be capable of launching payloads of between 70 and 100 tons into low-Earth orbit (LEO).

- *Dr. Condon* asked what kinds of missions are possible with this lift capability. *Ms. Guidi* said in addition to near-Earth objects, it will accomplish many missions. The Human Exploration Framework Team (HEFT) is a new version of the Exploration Systems Architecture Study (ESAS); both do architectural planning to identify capabilities needed to go to space. The lift capability for Mars would be 130 and greater to minimize the number of launches. *Dr. Condon* wondered how scalable this would be. It would be important to be able to add extra lift if needed. *Col. Collins* pointed out the need to also be able to scale it down; it's too big for the Space Station.

The SLS reference vehicle design best matches the authorization language. It does not have an upper stage right now. They also have existing assets to defray initial costs. But, they need money for payloads. They are trying to build a robust SLS program and are inviting industry to

contribute. NASA is pursuing 2 approaches for a more cost-effective SLS solution: SLS Study Contracts, and Government Requirements Analysis Cycle (RAC). They want to use information in their formulation, so they are convening technical interchange meetings, the first to be next week at Marshall Space Flight Center.

In parallel with SLS acquisition activities, the Constellation Ares contracts will continue through FY2011, until the SLS contracts are awarded, which minimizes workforce disruptions. Because the FY2010 appropriation is for Ares, work will be done at Marshall. The independent cost assessment will take place in April. For this they want people they do not have to re-train. (This could be an internal consultant.) After the cost assessment, they will be able to finish the report to Congress, hopefully in May. It would be good to get some indication of acceptability from the Office of Management and Budget (OMB) before sending it to Congress.

Broad Agency Announcement (BAA) study contract participants consisted of 13 teams awarded \$625,000 to \$7.5 million. They were a mix of aerospace firms, engine developers, and academics. The period of performance is six months. The teams develop concepts that are affordable and that maintain some money for follow-on efforts. There are four teams: Team 1, LOX/LH2/SRB Core, is addressing a family of Ares/Shuttle-derived vehicles. Team 2, LOX/RP Core, is addressing four concept development paths. Team 3, LOX/RP Modular Core, looking for synergy with the Air Force, is addressing modular, common-core diameter vehicles. Team 4, the Affordability Team, is addressing affordability, a key consideration in the development of the Con-Ops, functional flow derivation, and requirement development. Considerations include how to deploy the workforce, and how to operate differently to bring the cost down. By December 15, the teams were to complete the initial study approach and preliminary architectures; final review will be March 10, 2011.

In sum, this is not an official program, but they are making progress preparing for when it will be official. They are continuing with Ares contracts at the reduced Continuing Resolution level, which will be applicable to SLS. And, they are continuing with affordability strategies: NASA understands that improvements in its cost-estimating capability are needed. A major focus is how to take advantage of improvements.

Discussion

- *Dr. Grunsfeld* agreed that affordability is key, and *Ms. Guidi* acknowledged the challenge of living within those constraints.
- *Ms. Morgan* asked about commercial requirements. *Ms. Guidi*: The Commercial Orbital Transportation Services (COTS) program has two engines using hydrocarbon-based rocket propellant, which NASA also uses. They have found a lot of synergy with Air Force. Nevertheless, one size does not fit all. Replying to *Dr. Grunsfeld*, *Ms. Guidi* said they have not talked to all the players to see if anybody else wants a large-sized engine. They don't think we need the heavy size; they want to find synergies for the heavy lift at the lower end.
- *Dr. Condon* feared they might be building something big and then figuring out what to do with it, rather than starting with the goal and designing lift capability to achieve it. There

is a risk in building a generic heavy-lift vehicle in either compromising in a way that makes it not as suitable a vehicle than if they had started with an objective in mind.

Ms. Guidi agreed. But, HEFT and the Committee showed that you could have common objectives in various destinations, and they wanted technology that could serve multiple destinations. With as few as three launches, safety decreases. Furthermore, *Dr. Condon* thought they were at risk in developing generic equipment from overall cost of operations because we wind up with a suboptimal vehicle. If a heavy-lift vehicle is designed to accomplish a particular mission, do I risk having a vehicle that is so costly to operate that I limit myself to a mission that can be accomplished with that?

- *Mr. Holloway* pointed out that NASA has a history of not knowing costs to accomplish a vision within 30% or 40%. And we have to improve the design of the vehicle to do it. So, the concept must have flexibility to grow, which makes scalability important.
- *Ms. Guidi* reiterated that they do not have money to build multiple launching vehicles, so they will find the best design to accomplish most of the work. *Dr. Grunsfeld*: As soon as the vehicle is sent to ISS, we can have another discussion. They have spent twice as much as it cost to send something to the Space Station.
- *Col. Collins*: Changing strategic plans is most frustrating for an operations person. It is very difficult. She recommended that they stick with their decision as long as costs are kept under control. When they try to get the optimal vehicle, it never flies. It is better to have an adequate vehicle that flies. *Ms. Guidi*: We are trying to take control of destiny, but it is challenging. *Dr. Grunsfeld*: We are talking about affordability and jobs, but not safety. To pick a path that is affordable and safe, we need to be able to say, "It can't be done."

ETHICS BRIEFING—OFFICE OF THE GENERAL COUNSEL / ADAM GREENSTONE [FOR KATIE SPEAR]

Everyone was present for the briefing. Copies of the power points were distributed.

MEETING WITH THE ADMINISTRATOR

Administrator Charles Bolden entertained discussion on topics of interest to the committee.

- *Col. Collins* had three concerns: the Shuttle, ISS utilization (especially no missed opportunities), and commercial crew. This committee works closely with the Commercial NAC. It is early to look at operational issues, but never too early. Space radiation and orbital debris are other issues. *Admin. Bolden*: The role of any advisory committee related to crew is to look at NASA's mission. Agency leadership spent two days at Langley at a strategic planning workshop and will attend a Strategic Management Council at Goddard led by Simon Sinek. This carries through the completion of NASA's "why" statement. We tend to get sidetracked if we don't understand our purpose. NASA's "why" is exploration, not commercial space *per se*. We have to be trying to find new things at all times; commercial entities cannot do that. The President and Congress in the Authorization Bill say: "expand exploration beyond lower orbit," i.e., put meat

(money) on the vision. “A vision without resources is a hallucination.” NASA has to produce a heavy-lift vehicle of some type that can hold crew members on the way to Mars and intermediate places where research is done—the lunar surface now and then, maybe an asteroid. We can go to an asteroid, but asteroids “have a say.” We are trying to identify asteroids that are reasonable in terms of timing. The only way we can do any exploration is if we can forget about managing access to lower orbit, and that’s the purpose of commercial flight.

It is not reasonable to expect NASA to provide back-up for lower Earth orbit.

Admin. Bolden asked committee members to help him help commercial space flight succeed. ISS is the destination now, the anchor for human exploration. We can keep the Station viable through 2020 and soon will be certifying it to 2028, but after that, all bets are off. It is not a good business model for an entity lasting longer than 10 years. Everything we do is launched on a commercially acquired vehicle, even DoD’s Minotaur. There is no shortage of customers for putting things into space, but putting people into space is another matter. The Administrator’s job is, to the greatest extent possible to buy services available on the commercial market. If we use Minotaur, we must justify using it instead of some commercially available vehicle.

- *Dr. Condon:* Clearly, we need a heavy-lift vehicle to get to Mars, but the strategic plan posted on the Internet is dated 2006. It would be helpful to have a public declaration about where NASA is headed. For the last 50 years NASA’s workforce had a clear idea of purpose with concrete endpoints. We lack this now and the more Admin. Bolden can articulate and disseminate such statements, the more helpful it would be. NASA can be a great vehicle for exciting a whole new generation. Saying we are all about improving technology doesn’t have the same excitement about it. It suggests that the more you can articulate some clear goals and objectives, the more public support and also support within the workforce will be forthcoming. *Admin. Bolden:* The strategic plan is now at OMB for internal review. Sometimes Admin. Bolden is criticized because he “is not doing what the White House wants,” to which he replies, “The White House is a building.” In fact, Admin. Bolden has talked to the President, and the President is committed to human space exploration to Mars and an asteroid, and he has bought into the flexible path the Augustine Committee identified. He understands that to inspire kids we have to give them something they can strive for. Admin. Bolden came to NASA because there was a transportation system to space where we could construct more vehicles to go deeper into space. He wanted to walk on the Moon, then Mars. He stayed after the Challenger accident, and now he wants to get some of the new hires to the Moon and maybe Mars.
- *Dr. Condon* did not think the President’s vision was widely understood. *Admin. Bolden* thought that was purposeful. There is still conflict between commercial ideologues who think if NASA contributes anything, and if NASA has any kind of vehicle, that the commercial work is unimportant. But the commercial players are vital for access to space (commercial vehicles) and getting crew members to ISS. Infrastructure costs are the great impediment, e.g., running all the buildings at KSC has become prohibitive, but closing them does not mean those people will lose their jobs. *Dr. Condon* observed that

NASA appears to be in tug of war between the President and Congress, e.g., the President canceled Constellation, but Congress disagreed. The more clarity the Administrator can give to the direction in which NASA is headed, the better for public support and that of the workforce.

- *Mr. Holloway:* In two or six years there will be another President, and NASA needs to be ready for that transition, to have something that will sustain the next Administration. *Admin. Bolden* added that it must be affordable and sustainable—it's about multiple Congresses and multiple administrations, and it must make sense. Now we are trying to articulate who NASA is and where it is going. And, *Mr. Holloway* added, you need to communicate that to the world.
- *Admin. Bolden:* The President is surrounded by people who know that you cannot be as partisan as many want you to be. We are now focusing on this and trying to articulate the President's position. *Admin. Bolden* articulates what the President and Congress agreed to in the Authorization Bill, but people choose not to hear those things. Some want to put everything into commercial and wait 20 years or so to explore space. Technological development is important, but it is not the only important thing. Moreover, reducing the budget to 2008 levels would destroy both the commercial program and NASA's programs. They have to deliver around 2013.
- *Ms. Morgan* asked when the last survey was done. The perception is that NASA is going in circles and being yanked around. NASA appears to be wandering aimlessly, but that is not so, and we need to get that message out. *Admin. Bolden:* NASA is not trying to do any low Earth orbit flights—that's for commercial. They cannot survive as a business unless they produce something that pulls the launch provider. The growing commercial launch industry is depending on NASA. And, NASA cannot sustain a viable launch industry without other customers.

INTERNATIONAL SPACE STATION—SOMD/MARK UHRAN

Robotics progress is unprecedented. In January, the Special Purpose Dexterous Manipulator (SPDM or Dextre) was put to work on a real operations challenge moving cargo transfer container 3 from ELC-2 site 1 to site 2. The Russian EVA-27 completed its objectives, and both HTV-2 (with racks for Japan's research) and Progress 40P docked .

- *Dr. Grunsfeld* noted that all the Remote Power Controller Modules (RPCM) need to be changed out. *Mr. Uhran:* Different launch vehicles call for different constraints, e.g., time between arrivals. In fact, some rules had to be relaxed to accommodate the current volume of activity.
- *Col. Collins* asked whether research also had to be cut back. *Mr. Uhran:* This is not normal operations, but special circumstances. And, they really haven't ramped up the research yet, so the impact was not big, although it consumed crew time.

February 24, 2011, #133, the last assembly flight, will deliver a permanent multipurpose module and Robonaut 2. On April 19, 2011, Flight #134 will deliver the Alpha Magnetic Spectrometer 2 (AMS-2) and the ExPRESS Logistics Carrier 3 (ELC3) and swap out the Materials ISS Experiment 8 (MISSE-8). (They abandoned the original cryo-cooled element for AMS-2 and went back to a permanent magnet so it can stay on orbit the full 10 years.) June 28, 2011, flight #135 will transfer the Multipurpose Logistics Module (MPLM), with middeck cargo and consumables; remove the failed pump module assembly (PMA); install on the Lightweight Multi-purpose Experiment Support Structure Carrier (LMC); and deploy Picosat (post undocking). The Automated Transfer Vehicle (ATV) had its second flight (due to launch February 15, dock February 23, and undock June 4, 2011). SpaceX Falcon/Dragon demonstrations will take place this July and October. The combination of intense vehicle and intense robotics operations gives ISS the appearance of a busy shipping port.

Since Phase A (1984–1988), ISS mission requirements have spanned three domains for three disparate communities: scientific objectives, technology objectives, and increasingly economic objectives. The scope of mission requirements drove a spacecraft design that has an extraordinarily full-service capability at high-capacity throughput. Managing such a diversified, high-yield R&D portfolio requires an “honest broker” function that operates with objectivity, and value-based investment decision-making that represents best practices. ISS is capable of hosting multiple R&D communities: NASA’s exploration-driven research, including human biomedical research to extend crews farther into space, and engineering research necessary to develop and demonstrate the next generation of spacecraft; US national basic and applied research, a subset of capability made available for non-NASA organizations; and international utilization. Focus is now on the nonprofit organization (NPO) with agreements and memoranda of understanding (MOU) with private firms. This has been a successful model, but was done on a small scale, so the return was small. E.g., the National Institutes of Health (NIH) is already accepting and funding experiments to fly on ISS, and the US Department of Agriculture (USDA) is scaling up a program, as well. Governing policies are straightforward: the NASA Authorization Act of 2005 and 2010, the Federal Grant and Cooperative Agreement Act of 1977 (Chiles Act), and the NPR 5800.1 *Grant and Cooperative Agreement Handbook*. International partners, NASA, and NPO operate through the ISS Program Office. NASA missions are funded as usual; non-NASA missions, done with non-NASA funding, go through the NPO (the most significant feature will be its Board of Directors), which will look for high value R&D and find funding to move into the applications phase. Creating an outside organization will improve the communications structure, e.g., a scientist wanted to conduct experiments to produce vaccine, a private financier was looking for projects to invest in/fund, and NASA matched them up. This sort of thing needs to happen for 10 or 20 investigators, which this NPO will do—it’s more applications-oriented than basic research. With better communication and a dedicated organization, success will increase.

Of the four risks identified, conflict of interest is central, and the cooperative agreement notice was designed and set up to minimize that: the NPO cannot do its own research or take financial profit from other research done. The second risk is the NASA/NPO working relationship—they need each other. The third and fourth are requirements integration and prioritization, and cargo transportation availability. The law permits half of the ISS capacity to be made available to non-NASA researchers. Indeed, the entire success of the program depends on availability, but we

can't predict the strength of demand. They are ready to issue the cooperative agreement notice February 14, and to make the award by late spring this year.

- *Ms. Morgan* thought a chart for prospective users to show this would be helpful; then it would not appear to be entirely under NASA's control.
- *Dr. Grunsfeld* observed that we can carry operations and maintenance of ISS beyond the current date, but not forever.
- In response to *Col. Collins*, *Mr. Uhran* said the NPO would probably come from university associations, nonprofit research organizations, or for-profit aerospace organizations. A statutory requirement is that it be a newly constituted organization that is not subject to conflicts of interest with its parent organization.
- *Mr. Uhran* in response to *Dr. Grunsfeld*: According to OMB guidance, \$15 million is being offered, which implies that a small organization would be interested. For strategic communications, the board of directors must be highly credible. Part of the function is visibility and vocal representation to stimulate, develop, and market the ISS. NASA doesn't do this sort of communications effectively, but we want to change that so the right people are doing the outreach as a dedicated organization, not as a tacked-on function. The NPO has nothing to do with operations or payloads other than prioritizing, so key people will have to be in related organizations. This is very different from the Space Telescope, which has a single community. ISS cuts across science, technology, and commercial flight, and we have to have an organization that can tap into that expertise, not possess it themselves.
- *Col. Collins* asked for clarification of selection of members of the board of directors. *Mr. Uhran* said they have proposed a model, but it is not restrictive. In the model, board members are nominated by a committee of leading, chief scientists of the agencies involved. No existing board of directors can be used because every existing board was put in place to serve some other mission. Congress wants a board that has no conflicts of interest and serves this mission. The concept is explained in a 150-page report with an 18-page executive summary. This will be part of the evaluation process.
- *Col. Collins* asked about the inflatables Bigelow is developing. That technology was developed at JSC some years ago and some value was added through their own investment. *Mr. Gerstenmaier* and *Mr. Uhran*: At the beginning of development, there was a Space Act agreement to put an inflatable on the aft port, off to the side; two people could squeeze into it. This technology has been demonstrated. The objective is technology demonstrating a working relationship between Bigelow Aerospace and NASA. If NASA funds a project, it meets requirements for a NASA project. E.g., NIH is required to procure their own implementation partner, an organization experienced with payload. NASA evaluates proposals for cost and do-ability and is budgeted to pay for some of this.

Mr. Uhran concluded with examples of discoveries made in the microenvironment. In 1997, an electromagnetic levitator was constructed to determine thermophysical properties of a complex alloy, which, when solidified, forms a complex glass, essentially a metal of amorphous structure. This cannot be done on the ground because complex alloys are confounded by properties of the walls of the container. Discovered 17 years ago, liquid metal/plastic alloy has more than double the strength and plasticity of titanium and a low melting point; and last August was patented to Apple. This may be the third revolution in materials science: steel to plastics to thermoplastic equivalent/liquid. Such discoveries are slow to move into commercial application, and we need the right programmatic approach to get them into use. We need to put as much effort into using ISS as has been put into designing it.

SPACE COMMUNICATION & NAVIGATION (SCAN) RECOMMENDATION REVIEW

About two years ago, the NAC was briefed on futuristic upgrades. Many issues are involved, e.g., sharing bandwidth, but requirements are too broad. We recommended that an independent group look at SCaN. Jim Adams did that study, and a presentation will be made on Thursday (February 10). NASA has closely looked at deep space networks and optimal communications upgrades and is on the right track. Anyone interested can have access to the report.

UPDATE ON NASA'S COMMERCIAL SPACEFLIGHT INITIATIVES— ESMD/PHIL McALLISTER

Many issues have no final answer, e.g., there is no baseline with the Federal Aviation Administration (FAA) or requirements documents. Commercial Orbital Transportation Services (COTS) begins with the SpaceX agreement signed in 2006. Most milestones have already been met. Falcon 9's maiden flight was accomplished, as was the second Falcon 9 launch, which flew two full orbits, splashed down safely, and was recovered. It successfully demonstrated all 17 of the requirements. Some of the recovery was contracted, e.g., an Air Force helicopter, a commercial barge, a rented tug, their own people, and a diver. NASA had on site radar and P3 aircraft.

There are still two big flights remaining—June and September. Merging the two has been proposed. If their schedule slips they have to demonstrate to NASA that they can still achieve it, and explain the delay. Otherwise, NASA can terminate the agreement. With the analysis of robotic space craft, slippage was completely consistent with COTS. They are concerned about their delivery to the ISS, but the big benefit to having multiple flights is the reduction of risk. However, if there is a problem, they still have to demonstrate their other missions and would have to schedule another flight.

The other contract is with Orbital Sciences. They proposed one flight, and we asked them to do two. Additional money was made available for the new content, the COTS augmentation. (It was not for cost overruns.) Orbital's major milestones have been met, and the pad is being constructed at Wallops.

- *Mr. Holloway* asserted that you have to get there; there is no choice about that. If they do the right amount of preparation, and the right ground testing, there should be nothing wrong with the flight. The key is discipline on the ground and demonstrating that you're

ready for the event. A danger is not insisting on the right preparation. *Mr. McAllister:* To mitigate this possibility, they inserted additional test objectives after they are on orbit with round two.

In sum, both SpaceX and Orbital are making very good progress. Schedule slippage is consistent with NASA's own experience. It will be a challenging year ahead, but NASA stands to gain two new launch vehicles, two spacecraft capable of delivering cargo to ISS, and all the associated ground and launch infrastructure for about \$2 billion (vs \$8 billion to \$10 billion). COTS is not a panacea, but it shows that you can change the cost equation.

- *Dr. Condon* asked who retains liability in case of loss. *Mr. McAllister:* There are multiple contracts, so liability depends on the situation. The companies are commercially licensed so they are indemnified; personnel fall under the aegis of the FAA; property loss is self-insured. It depends on when the failure occurs and what specifically happens. We designed a class B payload, carrying things such as water and underwear (not mission critical). Carrying crew members would be a significantly different situation.
- *Mr. Holloway* wondered how it can cost so much for NASA. *Mr. McAllister* related that former Administrator Griffin was obsessed with this. The corporate mindset explains much of this regarding equipment—all the review, the time, the people involved. Decisions are made in a corporately developed mindset, e.g., on a SpaceX pad tour, they were shown an unimpressive hangar; when asked if they intended to upgrade, the answer was, “This one does the job and we have other expenses.” By contrast, a NASA manager would spend a year trying to justify having a better hangar.
- *Mr. Holloway* agreed that NASA is overwhelmed by bureaucracy today. He offered a second example: a third or more of the program's money goes to supporting the Institution. It is extremely difficult to close something. Thirdly, NASA overdoes the requirements.
- *Dr. Grunsfeld* thought this is successful because it has been made as simple as possible. But, *Dr. Condon* added, when government develops something like this they're self-insured and there's an inducement to be more cautious. *Dr. Grunsfeld:* Lockheed Martin would not risk human flight because failure would risk the entire company. NASA can afford to risk the whole company. But, those values may not be scalable. NASA is incentivized to add requirements and to add missions (which is politically sensitive).

Commercial Crew Development (CCDev) is funded by Recovery Act money. NASA received \$50 million to stimulate efforts within the private sector to develop and demonstrate technologies that enable human commercial space flight capabilities. February 1, 2010, five partners were announced: Blue Origin, Boeing, Paragon, Sierra Nevada Corp., and United Launch Alliance (ULA). All agreements were concluded by December 2010, except that ULA and Boeing received no-cost extensions. All companies contributed their own money.

Using a nontrade acquisition and partnering approach, NASA wants to facilitate development of US commercial crew space transportation capability with access to and from lower Earth orbit

(LEO) and ISS. \$6 billion was allotted to enable both Constellation and commercial flight to ISS, not one at the expense of the other. The cost-plus approach is not consistent with innovation. We need to maintain competition through certification. CCDev is achievable by late 2016, although there is debate about the size of the market for transportation to and from LEO. NASA is a big part of this market, and the NASA Authorization Act states that commercial vehicles are the primary means for ISS crew transportation.

NASA's Human Rating Requirement led to the Commercial Human Rating Plan (CHRP), which has evolved to the Crew Transportation System certification requirement. Requirements are tied to the mission—the load, the pressures. No authority has been given to guarantee safety to anyone other than NASA personnel. NASA is certifying only their own people for the ISS mission. Other people probably fall under the authority of the FAA. But, no one, not even FAA, has responsibility for people on orbit. At the program level they are giving the actual certification elements. They will get feedback from industry in May; already several hundred comments have been received.

They must either use a NASA type 2 standard or have their own standard that meets the intent—this has become a huge battle. Type 1 standards relate to crew safety. The certification team consists of six independent subject matter experts (Jim French, Deborah Factor Lapour, Joe Kazapoli, Wilt Faulkner, Max Zoboff, and Jay Green) who are now reviewing the documents to identify requirements that should be deleted.

We should not redundantly develop our own capability. An 1100 series document is in development to address this. Commercial providers are responsible for the full end-to-end system. Their director is the launch director and is responsible for the mission; NASA retains authority to pull NASA crew off a flight, whether the vehicle flies or not. NASA wants to give the companies flexibility, so NASA is trying not to be prescriptive. NASA is not funding any infrastructure, but they can use the VAB if they put it in their proposal.

- *Mr. Holloway* predicted that they will wind up paying for the Space Station; it's a false economy. *Mr. McAllister*: NASA is trying to not be in the broker mode negotiating agreements between commercial and other NASA directorates. They must comply with safety requirements, which includes suits. That must be determined in the market place, as must their approach (rental-car mode vs taxi mode).

It's not one size fits all, e.g., SpaceX has pressurized vehicles up and back, while Orbital's are pressurized only for the trip up. We invest in these companies because we want something back. Our vision is to have a dozen or so launches per year, i.e., routine access to space. In sum, the Shuttle will retire later this year, and only Russia and China will have the capability of getting people off the planet. This jeopardizes our lead in space. Therefore, we need commercial flight to maintain our capability. This is what drives the motivation for the commercial flight program. At the same time, access will enhance the productivity of ISS. NASA's focus is beyond LEO where commercial has no market, e.g., NASA is the only customer for heavy lift.

- *Col. Collins* asked whether NASA employees see commercial employees as competitors. *Mr. McAllister* couldn't speak for anyone else, but they do not have full support.

Philosophically some people probably view this as competitive. Limited resources should be spent on doing the things only NASA can do—let us do the hard stuff and go beyond LEO.

- *Ms. Morgan:* The consequences of failure of this program are so huge that people worry. If it fails, we will lose a whole generation of people in the field. She encouraged Mr. McAllister to have multiple providers. Soyuz, for one, has proven to be a very reliable partner.
- *Dr. Condon* appreciated the enthusiasm, but cautioned against overselling the concept. *Mr. McAllister* acknowledged that there are significant risks to the nontrade approach—you may not get exactly what you want. However, our tenuous space flight program should not depend on the prevailing political winds. Furthermore, with commercial involvement, going backward becomes much more difficult.
- *Mr. Holloway:* The business base for launching people into space will involve much more money than anticipated. Past accidents or close calls have resulted from design and testing problems, or environmental problems; never requirement problems. The critical thing for a long-term program that will survive is that it gets a couple dozen launches per year and that the vehicle is safe to fly and is certified that way. You have to be engaged with the technical people to make sure they are doing it the way you want it.
Mr. McAllister: It comes to insight and oversight—NASA people will be on the factory floor watching construction. How that will happen and operate has been the subject of major discussions and is defined in the requirements document.

In sum, CCDev1 is complete; CCDev2 evaluations are underway; the follow-on Commercial Crew Program is in planning; and NASA is attempting to define and implement a new way of doing human space transportation. But, there are many challenges to be addressed. Strong stakeholder support is critical to success. Everyone wants routine and accessible access to space, which will enable and expand the NASA mission.

- *Col. Collins* thought it would be good for the review team to look at the requirements. That essence of the importance of commercial space flight needs to be communicated within NASA (even at Headquarters) and to the public. That message is well-said, but not well-disseminated.
- *Mr. McAllister:* FAA licensing is being discussed. Ed Mango assigned a team to make a recommendation and report to him about whether we should license. The decision is Agency to Agency, and Admin. Bolden will make the ultimate decision. Someone has been detailed to FAA, and an FAA employee has been embedded here. NASA will probably sign an MOU with FAA for further work. He hoped NASA requirements will form the basis of the forthcoming FAA regulations. FAA is part of CCDev review.

DISCUSSION/RECOMMENDATION PREPARATION—COL. COLLINS

This group's next meeting will be May 2 or 3 at KSC and will be extended to SOMD and KSC staff. Topics should include a talk with Ed Mango, Director of the Space Transportation Planning at KSC; SpaceX's electronics approval system (its 21st century launch and both the horizontal and vertical process); and establishing 2011 meeting dates and locations. Col. Collins will send an email to set the date for a July meeting, probably at Johnson (it has to be before August 4 and 5), but will not go beyond that because members' terms expire in October.

The 2010 recommendations have been posted on the Web with responses to them. It has been a successful year for this committee and we have gotten good feedback.

For the 2011 work plan, Col. Collins presented an 11-item list for discussion (numbers 8 to 10 were combined):

1. ISS operations: transition from the shuttle era and ISS build-up to long-term science operations.
 2. Space Shuttle operations, including transition of shuttle to future launch systems. Workforce and infrastructure issues concerning shuttle program termination. NASA human launch systems (overlaps with OSMD).
 3. Future NASA human launch systems.
 4. Commercial launch of cargo.
 5. Commercial launch of crew.
 6. KSC Spaceport modernization.
 7. Human operations including
 - onboard future spacecraft
 - extravehicular activity
 - rendezvous & docking
 - displays and controls
 - micro-meteorite protection
 - radiation protection
- *Dr. Condon* suggested regrouping the list into categories of near-term, current, and future space issues.
 - *Dr. Grunsfeld* noted that there would be no extra-vehicular activity (EVA) capability until 2020, and hence no ability to visit Hubble. We have to visit Hubble before 2025 to recycle parts. Everything is on life extension, as is the whole ISS. For 2028, the ISS has a structural limitation. Space suits are a limitation because it takes two years to develop them.
 - We might recommend a Mars prelaunch, orbit, and landing test. After two weeks on the way to Mars, we will have to communicate by text messages, which could be simulated. *Dr. Grunsfeld* noted that maybe systems have to be easy to repair, rather than be operative for six months.

- NASA spends \$200 million per year on space flight life research, which will not be in this new program. *Dr. Grunsfeld* noted that people are now coming back in good shape, e.g., the bone loss issue has gotten much better through diet and exercise.
- *Col. Collins*: The big question is how to prevent NASA from missing opportunities and other research.
- *Mr. Holloway*: In regard to combining the two Dragon flights, we should have someone tell us about the requirements, which would have to be in May. What are their requirements to determine they are ready? What will they do to make sure they are ready to make that decision? The European Space Agency did a rigorous ground test to demonstrate that their software and hardware for ATV-2 were capable of the job. *Col. Collins* noted the difficulty of trying to make the real-time call. *Mr. Sieck* thought it should be approached not like it's a test flight, but like it's a real-time flight. *Mr. Holloway* summarized: These guys are motivated to be successful. They have to do testing before launch, decide what the rules are, and then do it.

The Committee made one recommendation that was submitted to the NASA Advisory Council on February 10, 2011. It can be viewed at the NAC's website at:
<http://www.nasa.gov/offices/nac/committees/index.html>

ADJOURNMENT

Mr. Keaton adjourned the meeting at 5:30 PM.

AGENDA

TUESDAY, February 8, 2011 - Room 7C61

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|---------------|---|
| 7:30 – 8:00 | Arrive/Convene Meeting |
| 8:00 – 9:00 | Discussion with Bill Gerstenmaier |
| 9:00 – 9:30 | Space Shuttle Update
- SOMD/Bill Hill |
| 9:30 – 10:30 | Heavy Lift/Space Launch System Briefing
- ESMD/Cristina Guidi |
| 10:30 – 10:45 | Break |
| 10:45 – 11:45 | Ethics Briefing
- Office of the General Counsel/Katie Spear |
| 11:45 – 12:45 | Lunch – MIC 7B (7J40) |
| 12:45 – 1:15 | Space Station Update
- SOMD/Mark Uhran |
| 1:15 – 2:00 | Space Communication & Navigation (SCaN) Recommendation Review
- Previous recommendations |
| 2:00 – 2:15 | Break |
| 2:15 – 3:15 | CCDev – Ops Perspective
- ESMD/Phil McAllister |
| 3:15 – 5:00 | Discussion / Recommendation Preparation
- Review 2010 accomplishments / recommendations
- Review 2011 work plan
- Establish 2011 meeting dates and locations
- Prepare recommendations / presentation |
| 5:00 | ADJOURN |